PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H01Q 21/30

A1

(11) International Publication Number: WO 99/26317

(43) International Publication Date: 27 May 1999 (27.05.99)

(21) International Application Number: PCT/SE98/01929

(22) International Filing Date: 27 October 1998 (27.10.98)

(30) Priority Data:

9704181-8	14 November 1997 (14.11.97)	SE
9800778-4	11 March 1998 (11.03.98)	SE

(71) Applicant *(for all designated States except US)*: RADIO DESIGN INNOVATION TJ AB [SE/SE]; P.O. Box 1223, S-164 28 Kista (SE).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: MALMGREN, Jens [SE/SE]; Heleneborgsgatan 6 C, S-117 32 Stockholm (SE).

(74) Agents: ÅKERMAN, Mårten, L. et al.; Albihns Patentbyrå Malmö AB, P.O. Box 4289, S-203 14 Malmö (SE).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

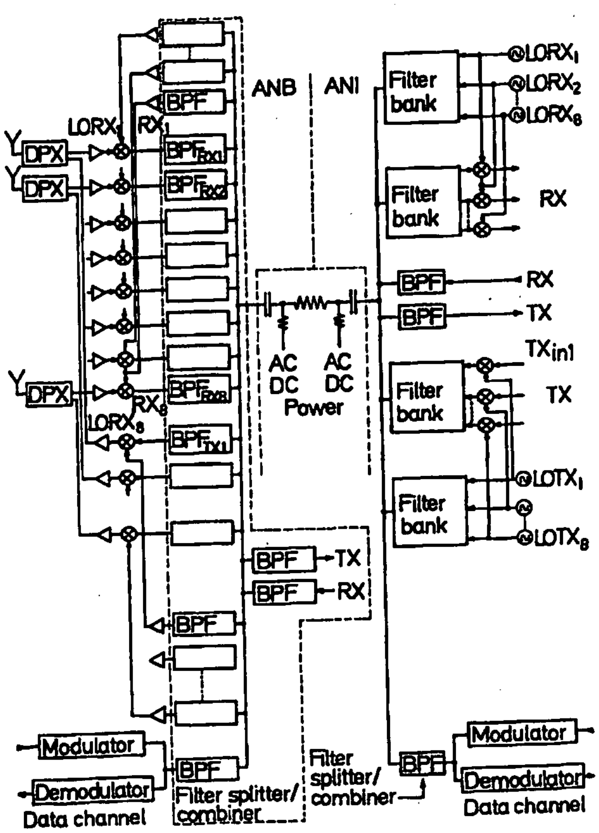
Published

With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: AN ANTENNA SYSTEM WITH A FEEDER CABLE

(57) Abstract

The invention relates to a phased array antenna system comprising an indoor equipment, a mast top equipment and at least one feeder cable between the indoor equipment and the mast top equipment wherein different kinds of signals are transmitted simultaneously on the at least one feeder cable.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

AN ANTENNA SYSTEM WITH A FEEDER CABLE

Field of invention

The present invention relates to an antenna system comprising an indoor equipment, a mast top equipment and at least one feeder cable between the indoor equipment and the mast top equipment.

Prior art

Today's base stations use omni-directional or tri-sector directional antennas. Figure 1 discloses for example the structure of a tri sector site. This requires only a few feeder cables from the groundbased equipment (ANI: Antenna equipment indoor; indoor equipment) up to the antenna box (ANB; mast top equipment).

In a phased array antenna system with multiple beams, the number of feeder cables is increased dramatically, and the cost of the cables becomes a significant part of the system cost. Also volume and weight become a problem. All cabling between indoor equipment and mast head equipment must be protected against lightnings. In the case of multiple feeder cables, this implies a large number of lightning protection devices, which is very expensive.

The object of the present invention is to achieve the above mentioned phased array-antenna system while reducing the number of feeder cables to a minimum.

Brief description of the invention

The above object is achieved by means an antenna system as claimed in claim 1.

The antenna system of the invention allows already installed feeder cables to be re-used. It also reduces the number of cables between base station and mast head equipment. The space occupied by cables, and the weight of the cables is reduced significantly. The cost of the cables is of course also reduced significantly.

By sending local oscillators frequencies on the same cable, the requirements on the local oscillators are reduced.

Mast head equipment must always incorporate lightning protection. By using a single cable instead of multiple cables, this protection is simplified.

Other features of the invention are set out in the dependent claims.

Brief description of the drawings

A detailed description of the invention is given below with reference to the following drawings, of which:

Figure 1 discloses the cable structure of a tri-sector antenna system in accordance with prior art;

Figure 2 discloses the cable structure of the antenna system according to the invention;

Figure 3 is a schematic circuit diagram of the mast top equipment ANB and the indoor equipment ANI according to Figure 2;

Figure 4 is a realisation of the splitter/combiner using a multiplexer;

Figure 5 discloses the frequency distribution on the feeder cable of different signals used in the invention;

Figure 6 is a table of the frequencies used in Figure 5.

Detailed description of an embodiment of the invention.

Figure 2 discloses the structure of the phased array antenna system in which the feeder cables of the tri-sector antenna in Figure 1 can be used. In Figure 2 each BTS (Base Transceiver System) is connected to ANI (Antenna equipment indoor) which in turn is connected to each of the ANB (Antenna box) via feeder cables. Each ANB is in turn connected to an antenna panel PAA with 8 columns. It is to be emphasized that the same feeder cables from the old antenna system in Figure 1 can be used in the antenna system in Figure 2. This means that the already installed cables of the tri-sector site in Figure 1 can be re-used in the antenna array system of the invention.

The underlying principle of the invention and the blocks ANI and ANB will now be described with reference to Figure 3.

The invention uses a method similar to that used in cable television, namely frequency multiplexing a number of signals on the same cable but in contrast to cable television, there are only a limited number of initial frequencies (in principle only the RX- and TX-frequencies). The following description refers to an implementation of NMT-450, but the same principle can be applied to other mobile telephone-, wireless local loop- or radio communication systems. The described system uses an antenna panel with 8 dipole columns, the signals to each dipole column being individually controlled. This means that from each antenna panel, 16 RF feeder cables are necessary. In an antenna system up to 20 or more antenna panels are combined. A 20 panel antenna would need 320 antenna feeder cables. With this invention, only 20 feeder cables are necessary (i.e. one cable for each panel, see Figure 2).

The invention consists of two parts: The indoor part and the mast head part.

As can be seen in Figure 3, each antenna element (dipole element) is connected to a duplexfilter in the mast head part where RX-signals and TX-signals are separated.The signals at RX frequency are amplified in a low-noise amplifier and then converted to a new frequency in a mixer using a local oscillator signal. It is then combined with the signals from the other dipole columns, transmitted on the common feeder cable to the indoor equipment where it is converted back to its initial frequency. In the same way, TX-signals are frequency converted in the indoor part, combined and transmitted on the common feeder cable to the mast head equipment, converted back to their initial frequencies and amplified to the needed output power before being fed to the antenna dipole column.

A critical component is the filter splitter/combiner. It consists of a number of bandpass filters that are connected together at one end. The bandpass filter transmits only the frequency of interest, where it presents a matched impedance. For all other frequencies, it presents a high reflection coefficient. As all bandpass filters are tuned to different frequencies, only one will load the feeder cable at each frequency. Other realisations are also possible, e.g. first a multiplexer which splits the frequency band in two or more subbands, each subband having its own filterbank, which can be seen in Figure 4. The multiplexer in Figure 4 could be arranged between the bank of bandpass filters and the capacitor of the feeder cable in the antenna indoor equipment in Figure 3.

Phased array antenna technology requires that a tight control of the phase shift of the signals being fed to the antenna is maintained. The phase shift can be controlled by measuring and comparing the phase of signals coming out of the multiplexer. It is then advantageous to send the reference signal at the RX- or TX-frequency, without frequency conversion.

The same feeder cable can also be used for DC or AC power supply, which will be described below.

The same feeder cable is also used for digital signalling between indoor and mast head equipment (data channel) by modulating the digital signals on a carrier. Wellknown modulation types as FM, FFSK, QPSK etc. can be used.

Also the local oscillators used for frequency multiplexing are included on the same feeder cable. As the same oscillators are used for up- and downconversion, the requirements on these local oscillators in terms of frequency stability and phase noise are reduced considerably. The achievement of the same local oscillator frequencies in the mast top equipment and the indoor equipment will be discussed in detail below.

In case a multibeam antenna according to the invention is replacing an existing antenna, the already installed feeder cables can be re-used.

Different frequency plans are possible, among others:

- LO under or over the RBS frequency band (over will be used), see Figure 6.
- RX-signals and TX-signals use the same LO or RX-signals occupy one frequency band and TX-signals another frequency band.
- The data channel can be placed anywhere, e.g. below the lowest RF frequency (below 100 MHz), in a band used for unlicensed transceivers (e.g. 433MHz), see Figure 6, or above the highest RF frequency.

In Figure 5 a specific frequency plan is disclosed. The distribution of the frequencies can be seen in this Figure. The signals are transmitted on the feeder cables with this frequency distribution. It should be realized that $LORX_1 - LOTX_8$ in Figure 5 correspond to LO (over) in Figure 6. TX_1 - TX_8 in Figure 5 correspond to TX (284,5 MHz – 396,5 MHz) in Figure 6. RX_1 - RX_8 in Figure 5 correspond to RX (102,5 MHz – 214,5 MHz) in Figure 6. The control channel (data channel) in Figure 5 uses 433 MHz and its bandwidth is approximately 2 MHz. The band-width of $RX_1 - RX_8$ and TX_1- TX_8 is approximately 5 MHz. The channel spacing between $RX_1 - RX_8$, $TX_1 - TX_8$, $LORX_1 - LORX_8$ and $LOTX_1 - LOTX_8$ is approximately 16 MHz. RX uses 452,5 MHz and TX uses 462,5 MHz as can be seen in Figure 5 and 6. A signal TX in_1; (462,5 MHz) is for example mixed by $LOTX_1$ (747 MHz) as is seen in Figure 3. The new signal frequency is now 747 MHz ± 462,5 MHz but the sum is filtered away. Thus the new signal frequency is 747 MHz – 462,5 MHz = 284,5 MHz in accordance with Figures 5 and 6. The frequencies of the local oscillators are multiplexed directly via a filterbank (preferably 8 bandpass filters) on the feeder cable as can be seen in Figure 3. DC- and AC-signals are injected directly on the feeder cable via an inductor which attenuates high frequencies (see Figure 3). In the mast top equipment the TX_{in1}, is converted back to its initial frequency by the same local oscillator frequency (i.e. 747 MHz – 284,5 MHz = 462,5 MHz) and amplified to a specific output power before it is transmitted by the antenna panel.

In the mast top equipment, TX-signals are reconverted to the original frequency, and RX-signals are converted to new frequencies using local oscillators. The same local oscillator frequencies are used in the mast top and the indoor equipment. The local oscillators in the indoor equipment are typically frequency synthesized oscillators using the same reference frequency (e.g. 10 MHz). The requirements on the local oscillators in terms of spurious, harmonics and noise are high in order not to degrade the performance of the base station. Also, because this is used in phased array antenna system, the phase difference between the different RX channels and different TX channels must be under control.

There are at least two possibilities to obtain the local oscillator signals in the masthead equipment.

1. Duplicate the synthesized oscillators of the indoor equipment. This is complex because the phase difference between the local oscillators must be controlled.

With a conventional synthesizer, the phase is not known at start-up. Also, phase noise can be a problem and degrade the sensitivity of the system.

2. Multiplex the local oscillator signals from the indoor equipment on the same cable as the other signals. Since the same local oscillator is used both in the indoor and masthead equipment, phase noise will be correlated in the up-conversion process and the down-conversion process, and thus the requirement on phase noise will be reduced for both indoor and masthead equipment. Also the relative phase of the local oscillators will be under control.

The multiplexed AC-signals or DC-signals are used as power supply in the mast top equipment. The multiplexed data signals on 433 MHz are used to control the mast top equipment, or to send information from the mast top equipment to the indoor equipment.

The above mentioned is only to be considered as a preferable embodiment of the invention, and the scope of the invention is only limited by following claims.

Claims

1. An antenna system comprising an indoor equipment (ANI), a mast top equipment (ANB) and at least one feeder cable between said indoor equipment and said mast top equipment, **characterized** in that different kind of signals are transmitted simultaneously on said at least one feeder cable.

2. An antenna system as claimed in claim 1, **characterized** in that said signals are multiplexed on said at least one feeder cable.

3. An antenna system as claimed in claim 2, **characterized** in that said signals are frequency multiplexed on said at least one feeder cable.

4. An antenna system as claimed in any of the preceding claims **characterized** in that said signal are RX-signals, TX–signals, local oscillator signals, control signals, AC-signals and DC-signals.

5. An antenna system as claimed in any of the preceding claims, **characterized** in that said antenna system is a phased array antenna system comprising an arbitrary number of antenna panels with an arbitrary number of antenna element columns.

6. An antenna system as claimed in claim 5, **characterized** in that each antenna element in said columns is connected to a duplexfilter in said mast top equipment where RX-signals and TX-signals are separated, said duplex filter is connected to an amplifier where RX-signals are amplified, which amplifier is connected to a mixer where said RX-signals are converted to a new frequency by means of a local oscillator signal, wherein said RX-signals on said new frequency are combined with converted RX-signals from other antenna element columns by means of a combining unit, preferably a bank of bandpass filter, and transmitted on said at least one feeder cable to said indoor equipment where they are converted back to their initial frequencies by means of same local oscillator signal.

7. An antenna system as claimed in claim 6, **characterized** in that a TX-signal (TX_{in1}) is frequency converted in the indoor equipment by means of a local oscillator signal ($LOTX_1$), combined with other converted TX-signals by means of a combining unit, preferably a bank of bandpass filter in the indoor equipment and transmitted on said at least one feeder cable to the mast top equipment, converted back to its initial frequency by means of same local oscillator signal, amplified in a amplifier in the mast top equipment to needed output power, wherein said amplifier is connected to an antenna element in said antenna panel for transmission of said TX-signal.

8. An antenna system as claimed in claims 6 and 7, **characterized** in that said combining unit is bandpass filters which are connected together at one end and constitute a splitter/ combiner in the indoor equipment and the mast top equipment, respectively.

9. An antenna system as claimed in any of claims 6-8, **characterized** in that said local oscillator signals from said indoor equipment are multiplexed directly via a bandpass filter on said at least one feeder cable and transmitted to said mast top equipment.

10. An antenna system as claimed in any of claims 6-8, **characterized** in that said local oscillator signals in the said mast top equipment are obtained by duplicating synthesized oscillators of said indoor equipment.

11. An antenna system as claimed in any of claims 6-10 **characterized** in that said AC-signals, DC-signals are injected on said at least one feeder cable via an inductor.

12. An antenna system as claimed in claims 6-11 **characterized** in that said at least one feeder cable is used for digital signalling by modulating, preferably FM, FFSK, QPSK, a digital signal on a carrier.

13. An antenna system as claimed in any of claims 6-12 **characterized** in that same local oscillator signals are used for both upconversion and downconversion.

14. An antenna system as claimed in any of the preceding claims **characterized** in that in case a multibeam antenna system, i.e. phased array antenna system, is replacing an existing antenna system, the already installed at least one feeder cable is re-used.

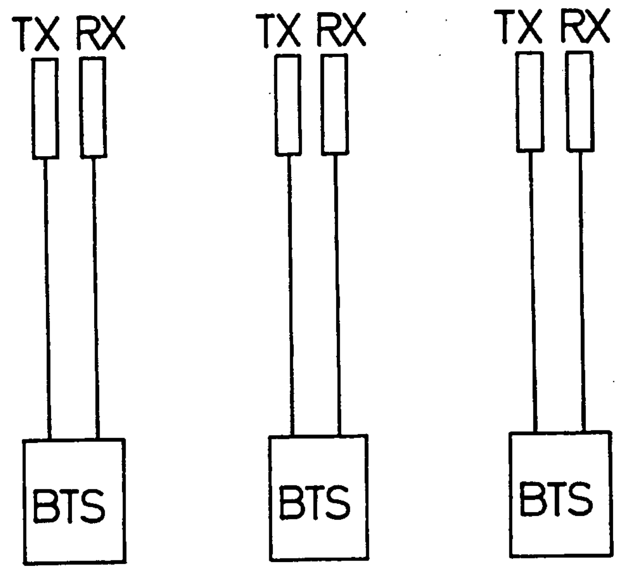


FIG. 1

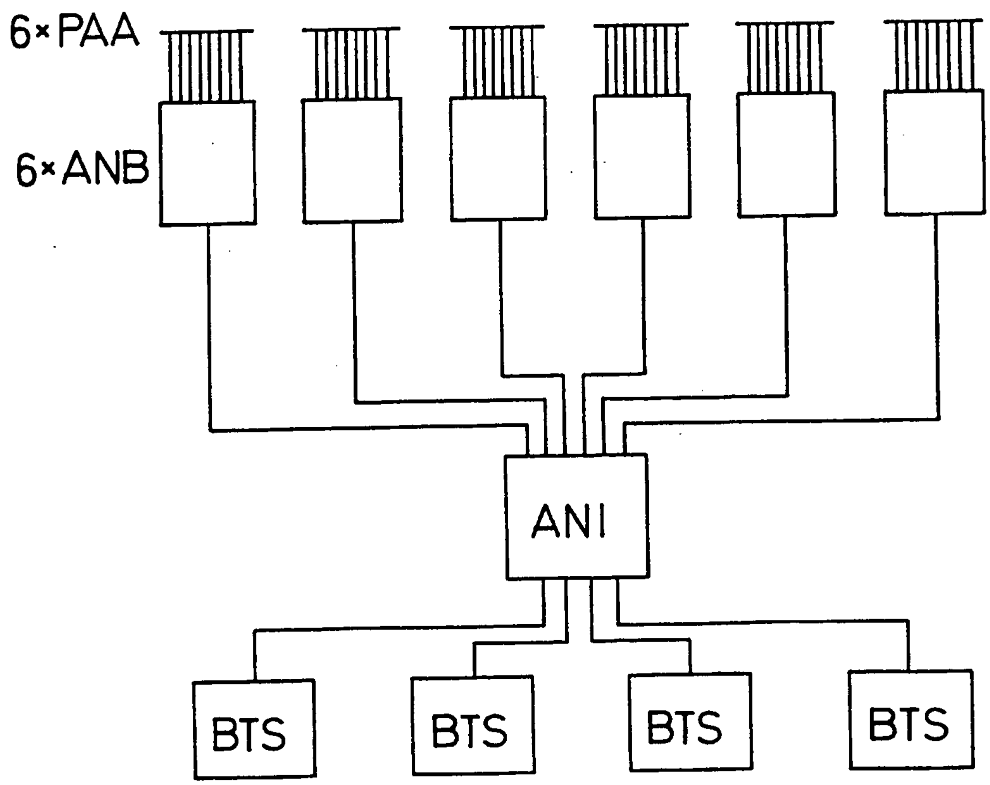


FIG. 2

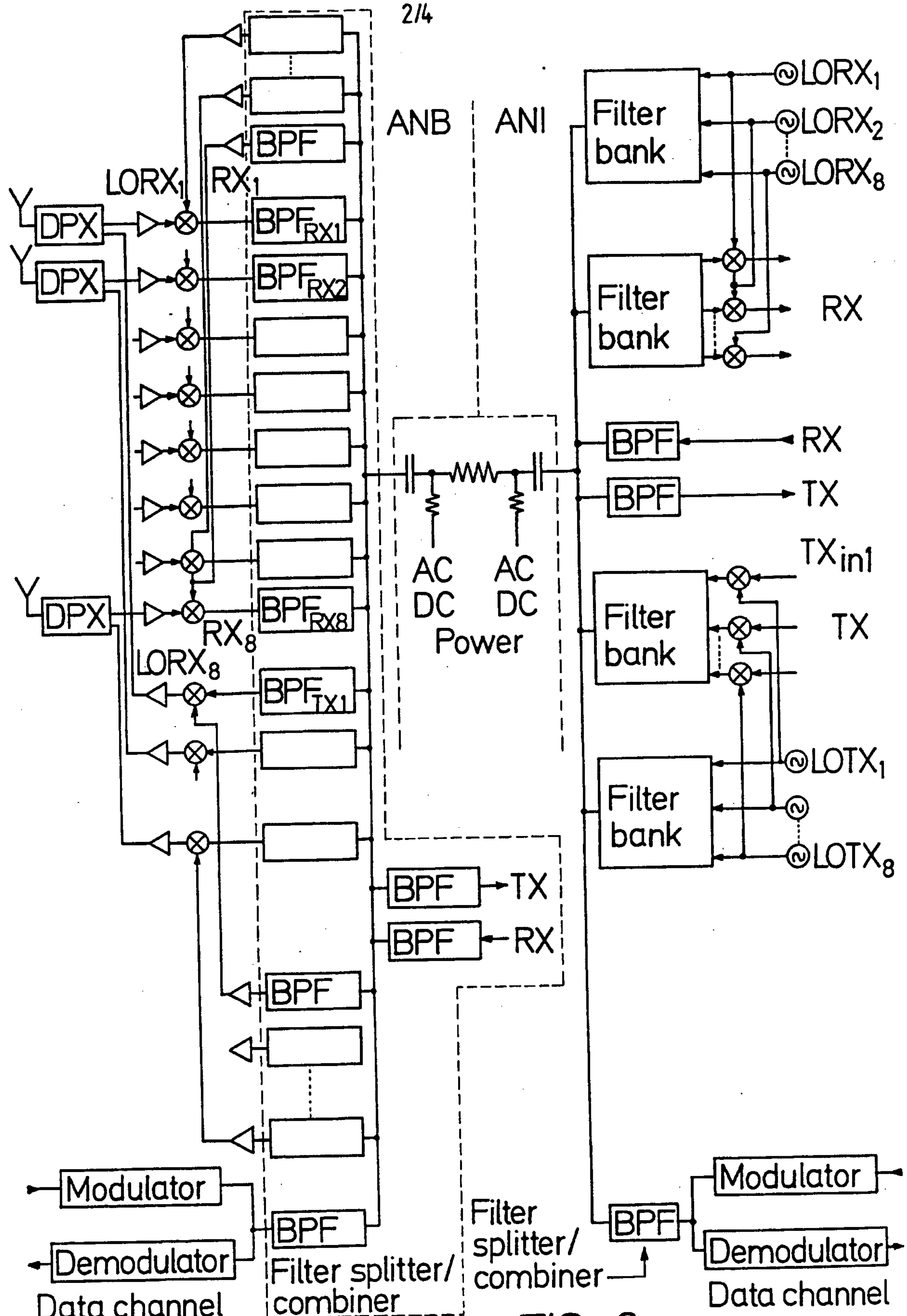

ANB
ANI
LORX$_1$
RX$_1$
DPX
DPX
DPX
BPF
BPF$_{RX1}$
BPF$_{RX2}$
BPF$_{RX8}$
RX$_8$
LORX$_8$
BPF$_{TX1}$
BPF
TX
BPF
RX
BPF
BPF
Modulator
Demodulator
Data channel
BPF
Filter splitter/ combiner
AC DC
AC DC
Power
Filter bank
LORX$_1$
LORX$_2$
LORX$_8$
Filter bank
RX
BPF
RX
BPF
TX
TX$_{in1}$
Filter bank
TX
Filter bank
LOTX$_1$
LOTX$_8$
Filter splitter/ combiner
BPF
Modulator
Demodulator
Data channel

FIG. 3

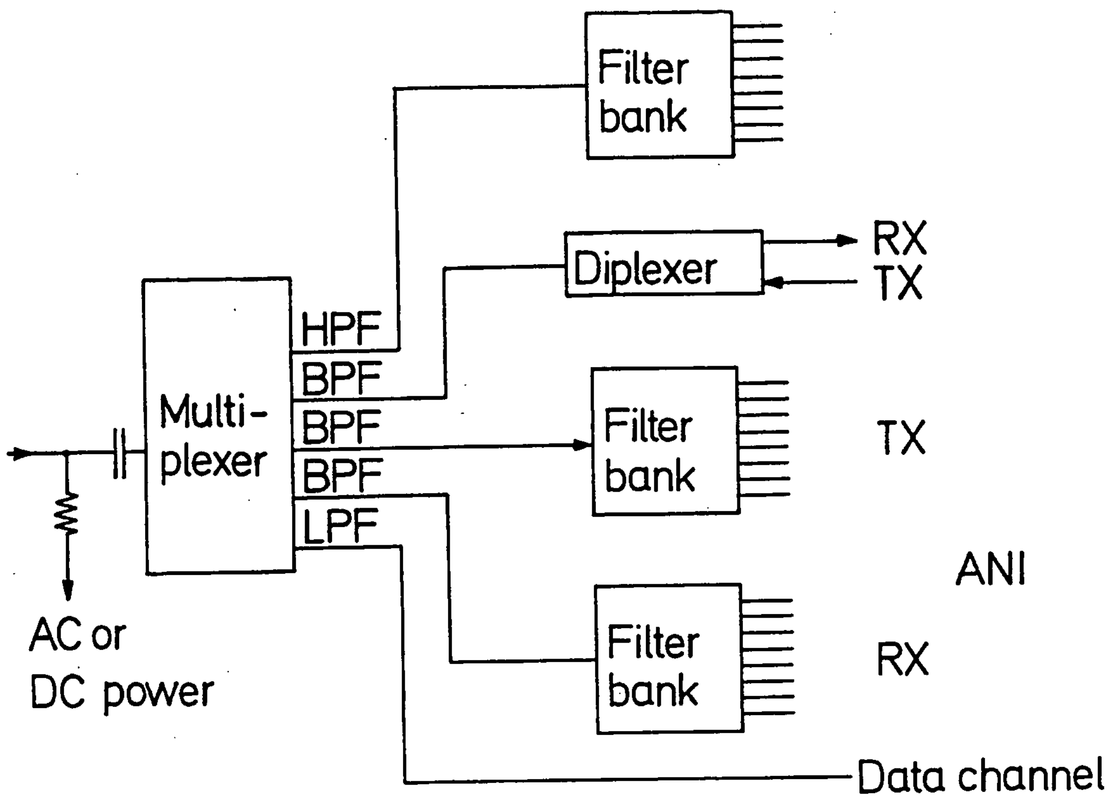

Filter bank
Diplexer
RX
TX
HPF
BPF
BPF
BPF
LPF
Multi-plexer
Filter bank
TX
ANI
AC or DC power
Filter bank
RX
Data channel

FIG. 4

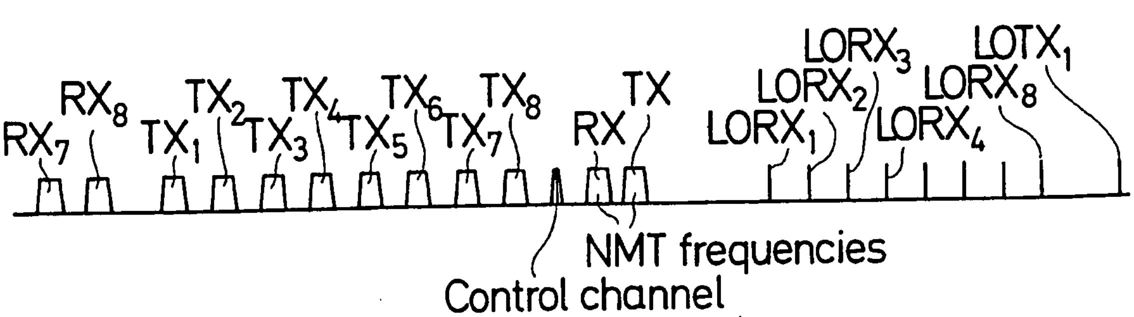

LORX3
LOTX1
RX8
TX2
TX4
TX6
TX8
TX
LORX2
LORX8
RX7
TX1
TX3
TX5
TX7
RX
LORX1
LORX4
NMT frequencies
Control channel

FIG. 5

MPX

NMT	RX MHz 452,5	
	TX MHz 462,5	
Channel spacing MHz 16		
RX MHz	LO (over) MHz	LO (under) MHz
102,5	555	350
118,5	571	334
134,5	587	318
150,5	603	302
166,5	619	286
182,5	635	270
198,5	651	254
214,5	667	238
TX MHz		
284,5	747	178
300,5	763	162
316,5	779	146
332,5	795	130
348,5	811	114
364,5	827	98
380,5	843	82
396,5	859	66

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 98/01929

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H01Q 21/30
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4734703 A (KAZUHIKO NAKASE ET AL), 29 March 1988 (29.03.88), figure 1, abstract --	1-14
A	US 5248988 A (MITSUYA MAKINO), 28 Sept 1993 (28.09.93), figure 2, abstract -- --------	1-14

[ ] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 April 1999	28-04-1999
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Rune Bengtsson Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT
Information on patent family members

02/03/99

International application No.
PCT/SE 98/01929

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4734703 A	29/03/88	JP 1678079 C	13/07/92
		JP 3040522 B	19/06/91
		JP 61227405 A	09/10/86
US 5248988 A	28/09/93	NONE	